

Inspection Considerations from the ISS Program

NASA In-Space Inspection Workshop 2014



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- The International Space Station has been permanently inhabited since November, 2000.
 - In that time, inspection has supported operations in many ways
 - Clearance assessments
 - Anomaly resolution
 - Leak location
 - The ISS Program has identified additional inspection needs to mitigate risks
 - Module leak location
 - Nondestructive evaluation of structural damage
 - Coolant leak isolation
 - MMOD damage indication
 - The ISS Laboratory is available to further advance the state of the art of in space inspection capability
 - Ongoing technical demonstrations to mitigate ISS risks
 - Support technology demonstrators for future mission capabilities as well as commercial advancement

- Inspection needs may come from mission objectives, anomalies, commercial objectives, or management of key risks.

- Examples of situations where inspection supports ISS operations:

- *Clearance Assessment:*

Design tolerances and physical flexing of vehicle have created need to measure clearances between moving and static parts. An example, measurements of clearance between Mobile Transporter configuration at outboard worksites and rotating Solar Alpha Rotary Joint were taken via photogrammetry to reduce uncertainty and authorize specific configurations.

- *Event Indication:*

An event that is undetectable via system performance measurements yet has potentially serious consequences has the potential to be detected or evaluated by inspection:

- Radiator panel face sheet deformation, did not result in a system leak and was undetected until identified in photographs. An inspection capability to either detect the dynamic event, or to notify based on before and after measurements. In addition, inspection to provide radiator performance, such as infrared imaging, can be used to aid in damage assessment or identify locations susceptible to similar events.
 - Detection of MMOD impact and assessment of resulting damage to components such as solar arrays, radiators, wire harnesses and connectors, or handrails. MMOD hits have been identified in photographs or by EVA crewmembers.

- Examples of situations where inspection supports ISS operations:

- *Cabin Leak Isolation:*

Location and evaluation of damage to the pressure integrity of the habitable volume via inspection would enhance existing capabilities. For example, we have experienced a small leak through a damaged hose that was very difficult to isolate with only atmospheric constituent and ultrasonic noise measurements. If we were to experience damage to the pressure shell, additional capability to quickly locate the damage site behind the operating equipment racks would allow quick response to plug the hole. Also, additional nondestructive evaluation methods would enhance the ability to assess any structural aspect of the damage.

- *Model Improvement:*

Deflection measurements have been used in conjunction with measured dynamic events, providing data to improve correlation between models and actual performance. An example, photogrammetry of solar array deflection during thruster firing has been used to refine modeling of the frequency and damping characteristics of the ISS arrays.

- *System Leak Isolation:*

The ability to detect and isolate ammonia coolant leaks to vacuum is limited. Leaks during manipulation of NH₃ quick disconnect operations have been easily managed. If we experience leaks due to other conditions, such as a deteriorating component or MMOD damage, isolation is more difficult and could be enhanced by inspection.

- ISS experience has identified the following inspection needs or opportunities:
 - Damage Assessment
 - Measure the height of sharp edge on EVA handrail or worksite
 - Measure the diameter of hole in structural member
 - Determination of depth and area of damage to pressure shell or structural beam, as well as the presence of cracks.
 - Imaging or characterization of damage to wire harness, cable, fluid line, or other routed equipment.
 - Nondestructive evaluation of structural components, supports analysis of potential overload events, life extension assessments.
 - Anomaly Resolution Support
 - Image hard to reach areas behind equipment racks, inside orifices of ORUs
 - Image or measure external hardware out of site or reach of current cameras or robotics
 - Image hardware to assess performance, such as thermal images for heater or coolant flow assessments
 - Acoustic measurement of operating equipment to support failure investigation
 - Low power, easily installed, possibly wireless sensors

- ISS experience has identified the following inspection needs or opportunities:
 - Leak Isolation
 - More quickly and accurately isolate cabin air leak, especially with reduced or eliminated crew involvement
 - Locate external ammonia system leak, especially with reduced or eliminated EVA
 - Event Monitoring
 - MMOD impact
 - Change of physical configuration, e.g. Radiator face sheet, solar array structural member, MLI blanket loose
 - Crew Efficiency
 - Automated inventory
 - Support to crew tended inspection or maintenance
 - Robotic inspection that offloads crew inspection
 - Other
 - Imaging or measurement of deflections or clearances
 - Imaging to provide configuration, especially in areas beyond the view of ISS cameras or at higher resolution than available.

Using ISS to Advance Inspection Methods Beyond ISS Needs



- The ISS Program continues to develop inspection methods to support the needs discussed on the previous pages.
- Future inspection capabilities may be needed to support missions beyond LEO.
 - Vehicle operation and maintenance will be more autonomous
 - Crew will be less dependent on ground teams for planning and operations as communication delay increases. Inspection to prioritize maintenance or to enhance response to events will be needed.
 - Robotic inspection can reduce the time crew are EVA.
- The ISS Laboratory is available for technology demonstrations in order to validate inspection capabilities in the space environment for any needs:
 - New technology to address ISS current risks
 - Capabilities that have potential to enhance ISS operations
 - Technical demonstrations that close gaps needed for future missions
 - Advancement of commercial inspection methods by proving them in space

The ISS Program continues to learn how to use inspection to support living in space.

How can you use the ISS to further advance inspection methods?